UNIVERSITI PUTRA MALAYSIA

A CONCEPTUAL MODEL OF CONSTRUCT ABILITY IN CONSTRUCTION PROJECTS

ADAM ABDELKARIM ABDULLAH

A CONCEPTUAL MODEL OF CONSTRUCTABILITY IN CONSTRUCTION PROJECTS

By

ADAM ABDELKARIM ABDULLAH

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science of Civil Engineering in the Faculty of Engineering Universiti Putra Malaysia

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Dedicated to my beloved Father and Mother
For their continual support and encouragement
May Allah (s.w.t.) bless them?

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : **L. Jawahar Nesan, Ph.D.**

Faculty : **Engineering**

The concept of constructability enhances benefits to the owner; by provide the construction input at the earliest stage, i.e. during the conceptual planning stage. The present research aims to identify the common design- related problems and the factors that delay the design and construction processes (stage of detailed design and commencing of construction activities, etc.). A questionnaire survey was conducted; followed by interviews with construction personnel including contractors, project managers, designers, expert engineers, etc.

The 'process complexity' was found to be the major factor that delayed the design and construction processes in the absence of construction input during the design phase. On the other hand, the main barrier to implement constructability was identified as the lack of construction experience of design organizations and the differences in contractual arrangement (the construction knowledge (Constructors) were not involved during project team meetings).

This research also revealed that the integration of experienced construction personnel into the earliest stages of the project as full- fledged members of the project team and comprehensive tracking (analysis, retrieving and storing of the efficient, workable methods and procedures that can be implemented to the current and future project) will greatly improve the chances of achieving a better quality project. Making this perceive specific knowledge available to designers at the right time. It is also important to obtain information as an integrated environment. The Information Management Model has been proposed to address the problems surrounding the construction environment, such as contractual arrangement and team relationships. It is facilitates the recording of the intent behind construction project decisions. Thereby, provide a complete project history, to integrate construction participant's knowledge and experience into the planning and designs phases. This knowledge should be collected before and after the construction of a project, to make it available for the planning and design of future projects. Design/Build approaches, is being suggested by the study to apply during the pre-construction and through whole project. Moreover, specialized- formal constructability programming, and comprehensive tracking have been argued as an essential approaches during the planning and design phase.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

KONCEP MODEL BAGI KEUPAYAAN BINAAN DI DALAM INDUSTRI PROJEK PEMBINAAN

Oleh

ADAM ABDEL KARIM ABDULLAH

Julai 2000

pengerusi : **L. Jawahar Nesan, Ph.D.**

Fakulti : **Kerjuruteraan**

Halacara Kontruktibiti menambahkan keupayaan pembinaan, memberi faedah kepada pemilik, dengan cara menyumbangkan data/ maklumat binaan di peringkat permulaan, sebahagiannya di peringkat halacara perancangan permulaan. Penyelidikan ini tertumpu kepada mengenalpasti masalah rekabentuk dan faktor lain yang melambatkan aturcara di peringkat rekabentuk dan binaan. Soal selidik dan temubual telah dilakukan di kalangan ahli binaan bangunan, termasuk pihak Kontraktor, Pengurus Projek, Perekabentuk dan juga Kepakaran Kejuruteraan.

"Halacara Bersusunlapis " adalah merupakan punca yang menyebabkan kelambatan di peringkat rekabentuk dan binaan, di sebabkan kekurangan bahan/ data pada peringkat rekabentuk, dengan kata lain, halangan utama untuk

melaksanakan projek binaan telah dikenalpasti sebagai kekurangan pengalaman binaan oleh pengorganisasian rekabentuk dan juga perbezaan pengurusan kontrak. (Kontraktor tidak terlibat di dalam mesyuarat projek di kalangan perekabentuk).

Kajian ini juga mendedahkan kesan pengalaman keindividuan bersepadu di kalangan ahli binaan dicurahkan semasa peringkat permulaan sebagai " full-fladged members" dari kumpulan projek, (kaedah menganalis , memperbetul dan penyimpanan kaedah kerja yang komprehensif, dan tatacara yang cekap boleh dilaksanakan terhadap projek semasa dan mendatang), akan berpeluang memperolehi projek yang lebih baik dan berkualiti.

Dengan memperbekalkan maklumat yang lengkap terhadap perekabentuk pada masa yang sesuai, juga dilihat sebagai penting, bagi memperolehi maklumat bersepadu keadaan persekitaran. Model Berinformasi telah dicadangkan untuk meningkat tahap pengalaman ahli binaan di peringkat perancangan dan rekabentuk. Maklumat ini perlu dikumpul pada masa sebelum dan selepas projek binaan, agar boleh digunakan untuk kerja perancangan dan rekabentuk untuk projek berikutnya. Kajian ini menyarankan agar kaedah "Rekabentuk dan Bina" digunapakai pada peringkat pra-binaan dan peringkat keseluruhan projek; manakala Kaedah Komprehensif telah dikenalpasti untuk digunapakai di tahap perancangan dan rekabentuk.

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I pray that Almighty God may bless all that have contribute in whatever way to the success of my studies at UPM but have not been mentioned here.

I certify that an Examination Committee met on 25 July 2000 to conduct the final examination of Adam Abdelkarim Abdullah on his Master of Science thesis entitled "A Conceptual Model of Constructability in Construction Project" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the examination committee are as follows:

D.N. TRIKHA, Ph.D.
Professor,
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

JAWAHAR L. NESAN, Ph.D.
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MOHD. RAZALI ABD. KADIR, Ph.D.
Associate Professor/Deputy Dean
Faculty of Engineering
Universiti Putra Malaysia
(Member)

SALAHUDDIN HASHIM, M.Sc.
Faculty of Engineering
Universiti Putra Malaysia
(Member)

MOHD. GHAZALI MOHAYIDIN, Ph.D.
Professor/ Deputy Dean of Graduate School
Universiti Putra Malaysia

Date: 27 NOV 2000

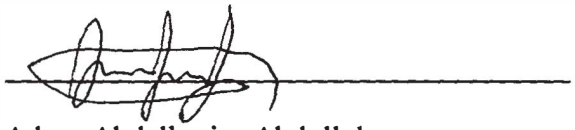
This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

KAMIS AWANG, Ph.D.
Associate Professor/ Dean of Graduate School
Universiti Putra Malaysia

Date: 11 JAN 2001

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



Adam Abdelkarim Abdullah

Date: 23 November 2000

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GLOSSARY OF TERMS

Client
The customer for construction.

Client adviser
The independent adviser, with a knowledge of construction and able to understand the clients business needs and objectives, including any special needs of the users. Engaged very early in the project to give impartial guidance on the best way to proceed.

Client project manager
The individual or organisation supplying the technical expertise to assess, procure, monitor and control the resources needed to complete the project. The client project manager should act in the client's interests and report directly to the project sponsor.

Concept design
An outline architectural and engineering design for the project, based on an early statement of client needs.

Construction
The process of constructing a building, a civil engineering project or engineering construction work, including new structures, maintenance, repair and refurbishment.

Construction project
A series of activities to define, design, construct and put to use construction work.

Consultant
An individual or organisation providing design, cost, management or other advisory services.

Designer
An architect, engineer, specialist consultant or contractor responsible for the design of part or all of a project.

Detailed design
The design which defines and details every component of the construction work.

Design review
A formal, documented, comprehensive and systematic examination of a design to evaluate the design requirements and capability of the design to meet these requirements and to identify problems and propose solutions

Procurement system
A method of obtaining and organising the external resources needed to complete a project.

Project execution plan
The statement of policies and procedures designed to ensure that every aspect of the design and construction of the project is properly undertaken within the client's constraints, and to achieve the stated objectives.

Project team
All the consultants, contractors, specialists and others, who come together to design, manage and construct a project.

Value management
A structured approach to the identification and evaluation of project objectives and of the means by which they may be achieved in order to obtain value for money, using a specialist facilitator and workshop techniques.

Quality management
That aspect of the overall management functions that determines and implements the quality policy.

Quality system
The organizational structure, responsibilities, procedures, processes, and resources for implementing quality management.

CHAPTER I

INTRODUCTION

The advent of information technology and automation in construction has brought major opportunities to construction firms. Automation technology will compete with human resources and other technologies for investment of scarce resource to continuously improve performances in construction firms. Methods of using CAD technology at construction site to increase the effectiveness of construction activities can create competitive advantage based on decreased project duration and decreased construction cost. Construction engineers can use CAD at site to automate existing processes (including planning survey control and layout, planning construction sequences and methods, and co-ordinating subcontractors.). Afield engineer in another firm used his personal computer (PC) and software to demonstrate beneficial applications of CAD in preparing lift drawing and planing concrete placement etc, several options are available to acquire new technology for automation. (Watson, Tucker and Walters, 1998).

Manufacturing has been a reference point and a source of innovation in construction for many decades. For example, the idea of industrialisation (i.e. prefabrication and modularization) has for a long time been viewed as one direction of progress, comes directly from manufacturing. Currently, computer integrated construction is seen as an important way to reduce fragmentation in construction, which is considered to be a major cause of existing problems, and this is also have their origin in manufacturing, where their implementation is well ahead compared to construction (Poulson, 1995).

Currently there is another development trend in manufacturing, the impact of which appears to be much greater than that of information and automation technology. This trend, which is based on a new production philosophy rather than new technology, stresses the importance of basic theories and principles related to production processes. However, because practitioners in process of trial and errors have developed it, the nature of this approach as a philosophy escaped the attention of both professionals and academic circles until the end of 1980's.

In construction, there has been rather little interest in this new production philosophy (value-based management, process redesign, concurrent engineering, etc). Construction industry is often seen in a class of its own, different from manufacturing. These peculiarities are often presented as reasons when well-established and useful procedures from manufacturing are not implemented in construction. However, in spite of these peculiarities of construction industry, the efforts of the expert researchers are going on to be improve the conflict gap between fragmented design and construction process. Traditionally, the quality of building comes from its design, the art and crafts developed over the centuries and the special techniques used in its construction. Industrial production processes have gradually replace the traditional ways of making objects. Recently the design and construction processes have oscillated widely between excessive commercialization of ornamentation, typical of late nineteenth century, and its absence in the "modern" movement.

The advent of a wider application of computers and robots in design and construction of civil Engineering projects has ushered a new era into the world of architecture and engineering where these new tools have received increasing attention by both researchers and practitioners around the world. One of their significant contributions is reflected in how they have allowed a very refined development and control desired forms that can serve human aspiration and spirit rather than the law of machine. This is enhanced by many other advantages of the new applications. It is estimated that the computer integrated design and construction can result in approximately 10 to 15 percent increases in the overall productivity with accompanying significant improvements in cost, safety, and quality. (Boyd C. Paulson, 1995).

Many organizational approaches and technological opportunity are available or under development to improve the integration and construction. The opportunity offered by information technology are especially promising combining organization approaches with stated –of- the art technologies in a systematic manner; will allow firms to derive the full benefits of computer aided design for construction. Computer automobile and aircraft manufacturers have taken the lead in improving the integration of design and manufacture and in using electronic standard to replace paper for many types of documents (e.g. Computer Aided Logistics and Support Initiative (CALS)). The construction industry has not yet used information technologies as effectively to improve and automate its design planning and operational processes. There is still widespread use of paper as a medium to capture and exchange information among participants in a typical construction project. There

is relatively little use of design and manufacturing automation tools that depend on computer- readable product descriptions. (Hans, 1999).

On the other hand, the construction industry could be rectified its systems, by selecting the appropriate method of contracting strategy, and choose the suitable tools, such Value Engineering, Partnering, Constructability, etc., to enhance the performance and better improve the situation. Therefore, this research has illustrated the context of constructability problems as one of these modern techniques and concentrating on its beneficial applications and as an important objective in all phases of a construction project. The designers play an important role in achieving superior constructability. Most project professionals, however, do not attempt to implement the constructability input through their projects' processes. One of the reasons behind this lack of constructability input, is the lack of formal communication and relationship that link the designers and constructors professionals (Watson, el, al., 1998).

Design and construction of building in general proceed sequentially, coupled through annotated sets of architectural and engineering drawings and specifications. Designers do not often anticipate the implication of their design on construction, and constructors' interpretation of the design solution often does not meet designer's intentions. This separation of design and construction processes has not only led to the decay of integration but also to a growing misunderstanding of the roles of each professional

Design of manufacturing has proved most effective when integrated into cyclical product development process (Liker, el, al., 1992). The understanding among the construction professionals within the same project will produce a service framework for the building project to formalize its information flows, to integrated design and construction into its linear facility delivery process and to approach more cyclical delivery process.

One of the most common construction problems as seen before is that early design decisions have a large impact on cost of construction. Normally, at this stage the designers, do not have enough construction expertise in design, and not involve the construction representative during design decisions. So, the design will come out but still unknown how and who will construct the building?. Integration of design and construction decision making, very important at the first stages of any project.

In addition, designers' drawing and specification often leave no or little space for contractor to adapt the design to the most economical construction methods. Moreover, owners, designers, contractors and construction managers often conflict about their goals. Design for construction is a methodology that addresses this issue.

This research encourages the implementation of Constructability in the way as an attempt to improve and support design and construction relationship for more project effectiveness. However, many building projects do not take advantage of this approach and miss opportunities for improving their organization's constructability and performance. Along with the others researchers focused much of their research on developing Computer – Aided (CA DfC), and they said that " To gain full

advantage from applying Design and Construction (D/C) Organizational approaches, technological opportunities should be combined", (Gijsbertus, el al., 1994).

Many construction practitioners and academics have believed that the appropriate implementation of constructability concept in the light of information technology will add a significant help to improve performance of the project delivery. (Hansen, el al., 1998).

Problem Background

The construction industry has been realized to identify the reasons why construction output does not allow satisfying and achieving the client's requirement and expectations. Not only that but also the problem are late completion, number of defects present during production, cost over -run and level of finished product quality. A number of studies produced by industrial sources have pointed out problems with building designers not producing building that can be built efficiently (Baldwin, 1997).

The experiences in construction so far mostly implemented in island of automation (No integration in applying the same technology and still depended on the old methods of construction). Such as in use of CAD by designer firms or cost estimating systems by contractors. Method of construction is developing at speed with pressure to utilize new materials and techniques. Also, the development of notation in architecture sees continued pressure to adopt new materials and techniques that have not stood the test of time and therefore can only be though of as experimental.